Original Article

PREVALENCE OF COMMON AND UNCOMMON ANATOMICAL VARIENTS OF CELIAC TRUNK BRANCHES ON MULTIDETECTOR COMPUTED TOMOGRAPHY ANGIOGRAPHY AND THEIR CLINICAL IMPLICATION IN A TERTIARY CARE CENTRE AT CHENNAI

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Abstract

Background: The celiac trunk is the unpaired branch of abdominal aorta, originating from the level of T12- L1 vertebrae supplying the structures developed from the embryological foregut. Normally the celiac trunk trifurcates into three branches (tripus Halleri) according to von Haller the common hepatic, the splenic and the left gastric artery. From the literature search, there have been many reported cases of anatomical variations in the celiac trunk's branching pattern. Knowledge of variations of the celiac trunk is important for planning surgical and endovascular interventional procedures.

Objectives:

- To analyze the prevalence of different types of celiac trunk variants in asymptomatic patients.
- To analyze the probable gender influence on anatomical variation.

Methods: A retrospective study involving 200 patients from Chennai-Kanchipuram districts were included in the study.

All the patients who are referred to the department of radiology for contrast enhanced computed tomography abdomen are included in the study however the patients with pathological conditions which could cause alteration in abdominal vasculature especially the celiac trunk as excluded from the study.

Prevalence of variations in the celiac trunk branching pattern was evaluated based on Uflacker classification and E. Pellagoni proposed classification of celiac trunk anomalies.

Results: Out of the 200 Contrast enhanced CT abdomen examined in this study, it was observed that trifurcation pattern of the celiac trunk with True tripod pattern (tripus Halleri) was more common (52.5% & 54.5% according to Panagouli and Ulfacker's classification respectively) than false tripod pattern (37.7% and 36% according to Panagouli and Ulfacker's classification respectively). Fair share of population with varying anatomical vascular variants were seen with Type II-Hepatosplenic trunk & Type V-gastro-splenic trunk were the commonest variants (3.7%) seen according to Ulfacker's classification. Additional branches (Panagouli type III) were observed in 4% of the study population. Subtle gender influence on anatomical variant among the classic pattern and anatomical variants were seen.

Conclusion: Multidetector computed tomography (MDCT) angiography is an effective tool for evaluating the variant anatomy of the celiac trunk branching pattern. Bifurcation pattern and celiac trunk with additional branches can be commonest variants second only to tripod pattern. Pre-surgical and pre-endovascular interventional evaluation of such variants is very important in order to avoid the vascular complications.

Keywords: Celiac trunk, Multidetector computed tomography (MDCT), hepato-splenic trunk, gastro-splenic trunk.

INTRODUCTION

The celiac trunk originates from the abdominal part of the aorta, at the level of T12- L1 vertebra [1,2,5,6,11]. Normally the celiac trunk trifurcates into three branches (tripus Halleri) according to von haller [2, 3] the left gastric artery, which runs through the smaller curvature of the stomach; the common hepatic artery, which divides into gastro-duodenal for the pancreas and duodenum vascularization, and its own hepatic artery, which will supply the liver; and the splenic artery, which follows tortuous by the posterior superior margin of the pancreas to the spleen [1,2,5,8]. This normal trifurcation variant of celiac trunk (tripus Halleri) in most studies was 75-85%, the bifurcation type seen in 7 – 13 % of the population, absence of celiac trunk is rare, affecting 0.2% of the individuals and other variants accounts for 1-2% [2,4,5,8].

During the embryological developing process of the abdomen, the three primitive arteries related to the digestive system viscera correspond to the celiac trunk, superior mesenteric artery and inferior mesenteric artery [5,10,12-14]. The longitudinal anastomosis anterior to aorta forms the omphalo-mesenteric artery, the anterior longitudinal anastomosis, namely between the future celiac trunk and the superior mesenteric artery, giving rise to the development of the arterial hepatic trunk [10]. In the absence of a celiac trunk, the descending and anterior longitudinal anastomoses regress completely; however, the roots of the ventral segmental arteries do not. The 10th primitive root of the ventral segmental artery becomes the left gastric artery; the 11th becomes the splenic artery; the 12th becomes the common hepatic artery [10].

According to Gluck, Gerhardt, Schroder [9] knowledge of celiac trunk variations is important for surgeons during various procedures such as hepatic transplantation, laparoscopic surgery, radiological interventions as well as penetrating lesions in the abdomen [5,9,13,14]. In addition, knowledge of unique variations of celiac trunk absence may be useful in planning and performing radiologic interventions such as celiac and chemoembolization of liver tumors. Changes in the celiac artery may increase both the difficulty and the risk of radical gastrectomy [5,9,10,13].

This information motivated this study, which has as objective to demonstrate the prevalence of anatomical variations of the celiac trunk.

MATERIALS AND METHODS

This was a retrospective study carried out on patients referred for contrast enhanced CT abdomen after obtaining informed consent in a tertiary care center in Chennai.

PHILIPS INGENUITY 128 slice CORE, made in the Netherlands was utilized for CT image acquisition.

- Non-enhanced scans were acquired first, followed by 75- 80 ml/s of LOCM at an injection rate of 4- 5 ml/s via dual pump injector and 60 ml of saline chase with a minimum post threshold scan immediately following bolus tracking.

A total of 200 patients (111 males and 89 females) referred for contrast enhanced CT abdomen at a tertiary care center at Chennai from January 2021 to March 2021 were included.

After obtaining written informed consent, Maximum intensity projection (MIP) and Volume rendering images of CT and its branches analyzed for anatomic variants. Any conditions which would cause alteration in CT vascularity are excluded from the study. Final configuration and variants were confirmed by a senior radiologist. Patient's age, gender, anatomic variants of the CT (recorded in two classification; the Uflacker classification of celiac trunk anomalies and the classification proposed by Panagouli E et al. classification were recorded in the patient data sheet.

INCLUSION & EXCLUSION CRITERIA:

- Patients who are referred to the radiology department for CECT abdominal imaging are selected for the study.
- Patients with pathological conditions which could alter the normal vascular pattern of the celiac trunk and patients not willing to participate in the study were excluded from the study.

DATA ANALYSIS

Statistical analysis using SPSS version 20.0 was done to determine prevalance of CT variants and its association with gender and age are analyzed. The P value was set at 0.05.

Table 1: Uflacker's classification of celiac trunk anomalies

TYPE	DESCRIPTION
Type I = trifurcation	
Classic pattern (I-C):	**The CHA, SA and LGA have a common point of origin from the celiac trunk.**
Non classic pattern (I-NC):	**CHA and SA have a common point of origin with the LGA demonstrates a variable points of origin**
Type II = hepato-splenic trunk	**CHA and SA have common trunk with the LGA arises separately from aorta**
Type III = hepato-gastric trunk	**CHA and LGA have common trunk with the SA arises separately from the aorta or SMA**
Type IV = hepato-spleno-mesenteric trunk	**CHA, SA and SMA have common trunk with the LGA arises separately from the aorta**
Type V = gastro-splenic trunk	**LGA and SA have a common trunk with the CHA arises separately from the aorta or SMA**
Type VI = celiaco-mesenteric trunk	**Celiac and SMA have a common trunk**
Type VII = celiaco-colic trunk	**The middle colic artery and the celiac have the same trunk**
Type VIII = no celiac trunk	**No celiac trunk with the CHA, SA and LGA arises directly from the aorta**

Note: CHA – Common Hepatic Artery, SA- Splenic artery, LGA – Left gastric artery.

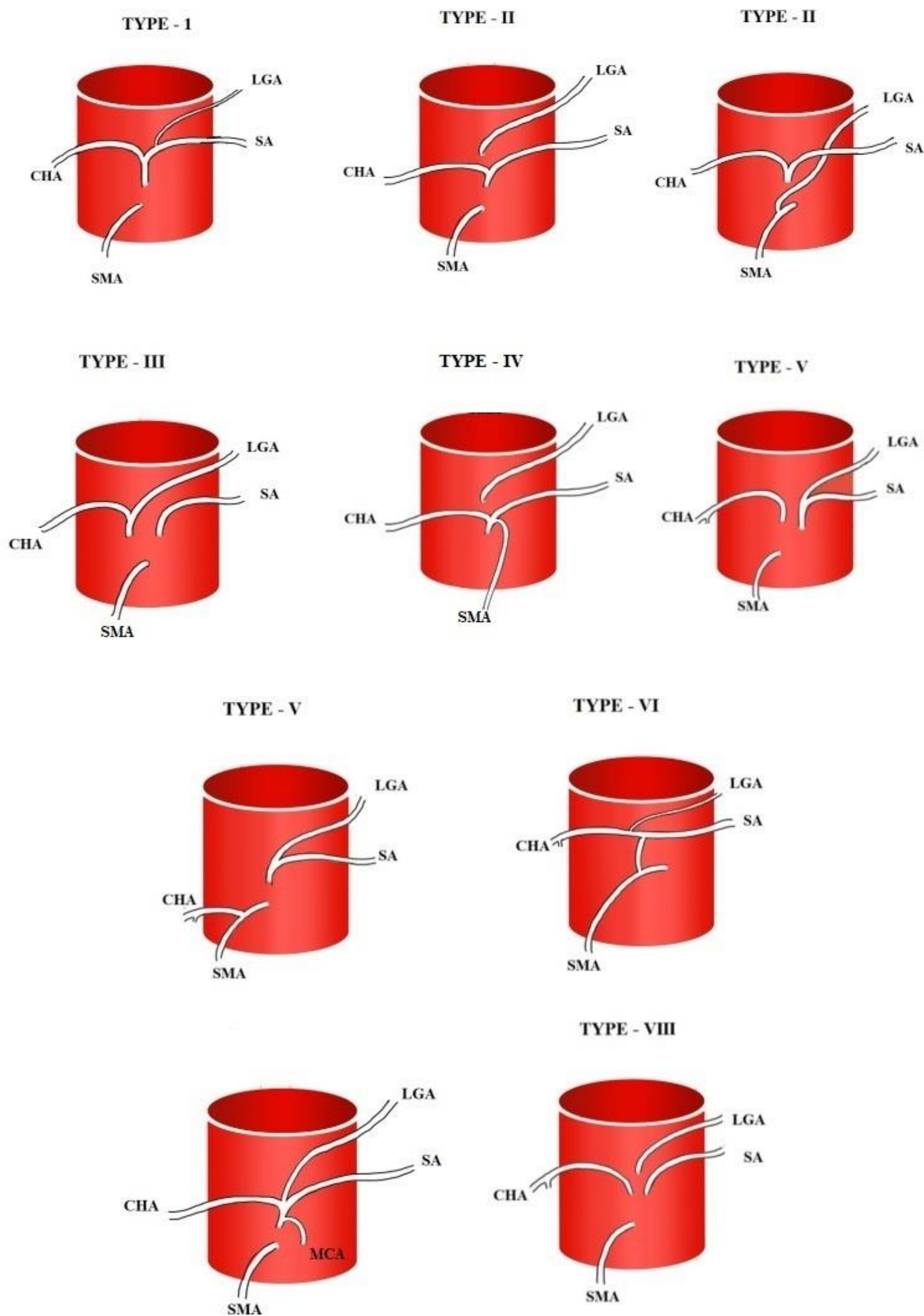

Figure 1: Uflacker's classification of celiac trunk anomalies

Note: CHA – Common Hepatic Artery, SA- Splenic artery, LGA – Left gastric artery, SMA – Superior Mesenteric Artery, MCA – Middle Colic Artery.

Table 2: Panagouli classification of celiac trunk anomalies

TYPE	DESCRIPTION
Type I	**Trifurcation of the CT into LGA, CHA and SA**
Form 1	**True tripod – common origin of LGA, CHA and SA (Tripus Halleri)**
Form 2 **Form 2a** **Form 2b**	**False tripod – division into two branches while the third branch arises earlier along the celiac trunk.** **LGA is the first branch.** **CHA is the first branch**
Form 2c	**SA is the first branch**
Type II **Form 1** **Form 2** **Form 3** **Form 4** **Form 5** **Form 6** **Form 7** **Form 8** **Form 9**	**Bifurcation** **Hepatosplenic trunk, LGA arising from the AA.** **Hepatosplenic trunk, no normal LGA.** **Hepatosplenic trunk and gastromesenteric trunk.** **Splenogastric trunk, CHA arising from the AA.** **Splenogastric trunk, CHA arising from the SMA.** **Splenogasrtic trunk and hepatomesenteric trunk.** **Hepatogastric trunk, SA arising from the AA.** **Hepatogastric trunk, SA arising from the SMA.** **Hepatogastric trunk and splenomesenteric trunk.**
Type III	**Additional Branches.**
Type IV	**Celiacomesenteric trunk (common origin of the CT and the SMA artery).**
Type V	**Variations in the origin of the CHA.**
Type VI	**Hepatosplenomesenteric trunk (common origin of the CHA, SA and SMA–LGA originating independently or as a branch of the others).**
Type VII	**Absence of the celiac trunk (LGA, CHA and SA are rising independently).**
Type VIII	**Splenogastromesenteric trunk (common origin of the LGA, SA and SMA–CHA originating independently or as a branch of the others).**
Type IX	**Splenogastric trunk giving rise to a common inferior phrenic trunk.**
Type X	**Celiac-bimesenteric trunk (common origin of the CT, SMA and IMA)**

Note: CT- Celiac Trunk, LGA – Left Gastric Artery, SA – Splenic Artery, CHA – Common Hepatic Artery, SMA – Superior Mesenteric Artery, IMA – Inferior Mesenteric artery

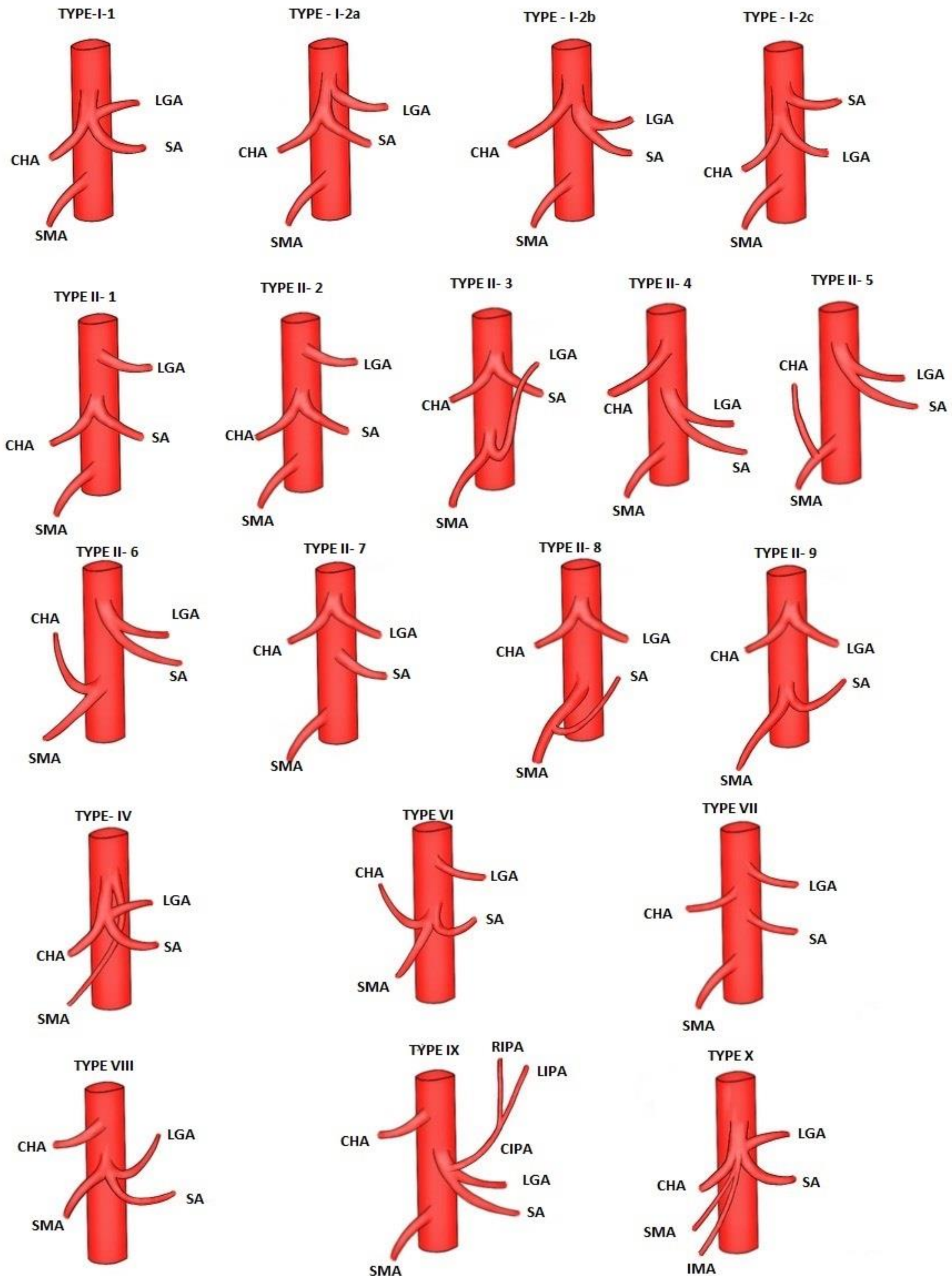

Figure 2: Panagouli classification of celiac trunk anomalies

Note: CT- Celiac Trunk, LGA – Left Gastric Artery, SA – Splenic Artery, CHA – Common Hepatic Artery, SMA – Superior Mesenteric Artery, IMA – Inferior Mesenteric artery, CIPA – Common Inferior Phrenic Artery, RIPA – Right Inferior Phrenic Artery, LIPA – Left Inferior Phrenic Artery.

RESULTS

Table 3: Age distribution of the study population.

Age	No
<45yrs	104
>45yrs	96
Total	200
Mean & SD	44±14yrs
Median	43yrs

Out of the 200 participants included in the study 104 were above the age of 45 years and 96 participants below 45 years with a mean and standard deviation of 44±14 years and median age 43 years.

Table 4: Gender distribution of the study population.

Gender	No
Male	111
Female	89
Total	200

111 male participants were included in the study and 89 female participants.

Table 5: Percentage distribution of celiac trunk variants of study population by Panagouli classification.

Panagouli Classification Types	No.	Percentage
Type 1-1	105	52.5%
Type-1-2a	72	36.0%
Type-1-2b	0	0.0%
Type-1-2c	0	0.0%
Type II-1	7	3.5%
Type II-2	0	0.0%
Type II-3	0	0.0%
Type II-4	1	0.5%
Type II-5	6	3.0%
Type II-6	0	0.0%
Type II-7	0	0.0%
Type II-8	1	0.5%
Type II-9	0	0.0%
Type-III	8	4.0%

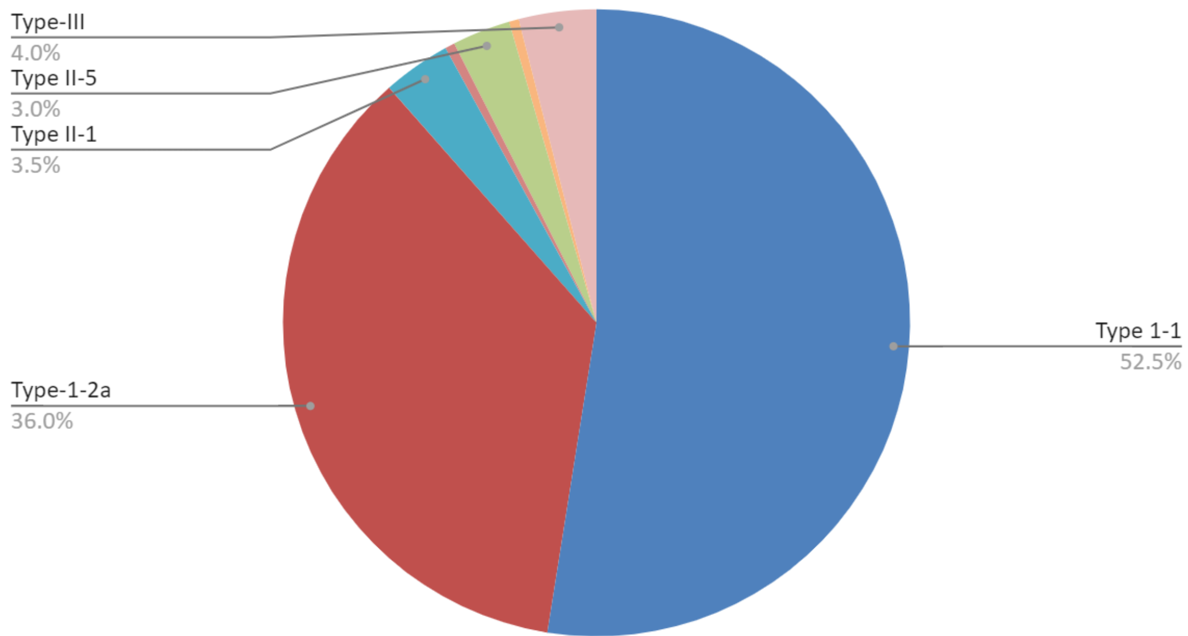

Figure 3: Pie chart diagram shows percentage distribution of celiac trunk variants of study population according to Panagouli classification.

On studying the pattern of celiac trunk variants by Panagouli classification, it was observed that a majority of 52.5% of the study population fell into the category of Type I-1 (Type I- Form 1) which is True tripod common origin of left gastric, common hepatic and splenic arteries (Tripus Halleri) (Figure 7), followed by Type I-2a (36%) under, which is False tripod where there is division into two branches while the left gastric artery arises earlier along the celiac trunk. Followed by 8 participants (4%) showing type III (Additional branches) (Figure 9), 7 participants (3.5%) showing type II-1 (Bifurcation of hepatosplenic trunk and left gastric artery arises from abdominal aorta) and 6 participants (3%) showing type II-5 (Bifurcation of splenogastric trunk with common hepatic artery arising from superior mesenteric artery) (Figure 8).

Table 6: Percentage distribution of celiac trunk variants of study population by Uflacker classification.

Uflacker's classification of celiac trunk anomalies	No	Percentage
Type I-c	104	54.5%
Type-I-NC	72	37.7%
Type II-Hepatosplenic trunk	7	3.7%
Type-III-Hepatogastric trunk	1	0.5%
Type-IV-hepato-spleno-mesenteric trunk	0	0.0%
Type V-gastro-splenic trunk	7	3.7%
Type VI -Celiaco-mesentric trunk	0	0.0%
Type VII-celiaco-colic trunk	0	0.0%
Type-VIII-no celiac trunk	0	0.0%
	191	100.0%

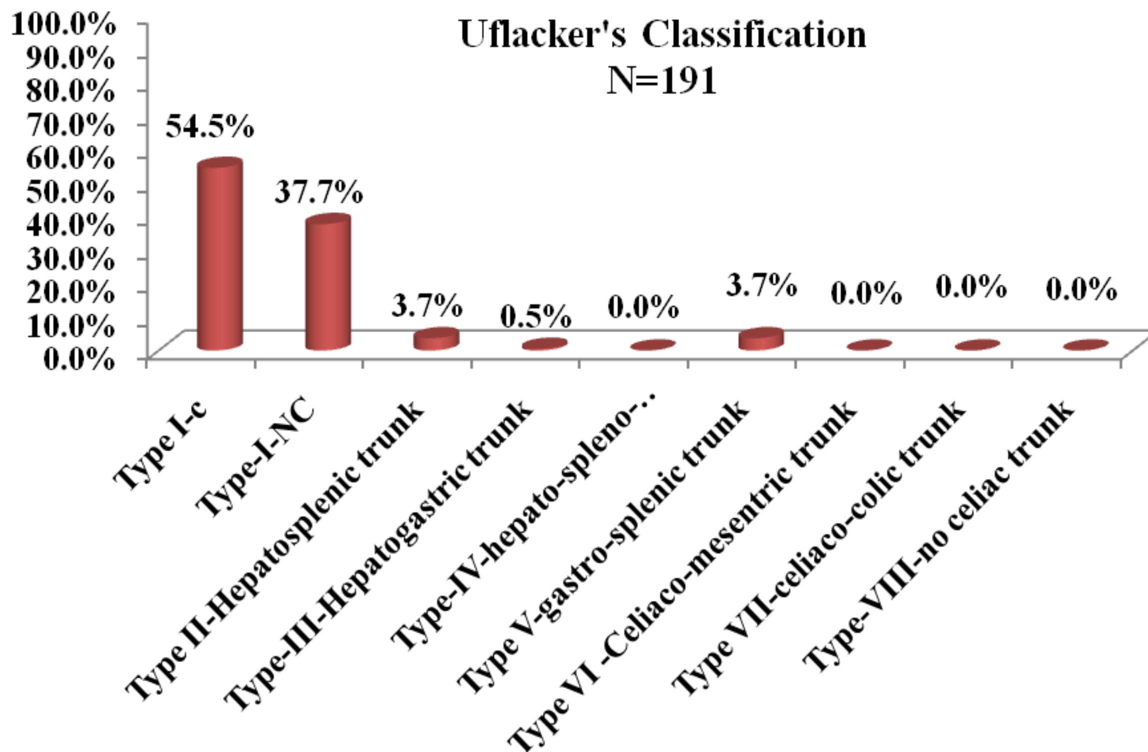

Figure 4: Bar diagram shows percentage distribution of celiac trunk variants of study population according to Uflacker's classification.

On studying the pattern of celiac trunk variants by Uflacker classification it was observed that 54.5% of the participants fell under the Classical pattern Type I-c (Figure 5) where the common hepatic, splenic and the left gastric arteries have a common point of origin from the celiac trunk, followed by 37.7% under the Non-Classical type I-NC where the common hepatic and splenic arteries have a common point of origin with the left gastric artery demonstrating a variable point of origin. 7 participants (3.7%) in Type II-Hepatosplenic trunk &Type V-gastro-splenic trunk (Figure 6) each and 1 participant (0.5%) in Type III-Hepatogastric trunk.

Table 7: Gender-wise distribution of celiac trunk variants of study population by Panagouli classification.

Panagouli Classification types	Male	Female	Total	*p* Value
I- 1	55(49.5%)	50 (56.2%)	105	0.314
I- 2a	43 (38.7%)	29 (32.6%)	72	
II- 1	2 (1.8%)	5 (5.6%)	7	
II- 4	1 (0.9%)	0 (0%)	1	
II- 8	0 (0%)	1 (1.1%)	1	
II-5	5 (4.5%)	1 (1.1%)	6	
III	5 (4.5%)	3 (3.4%)	8	
Total	111 (100%)	89 (100%)	200 (100%)	

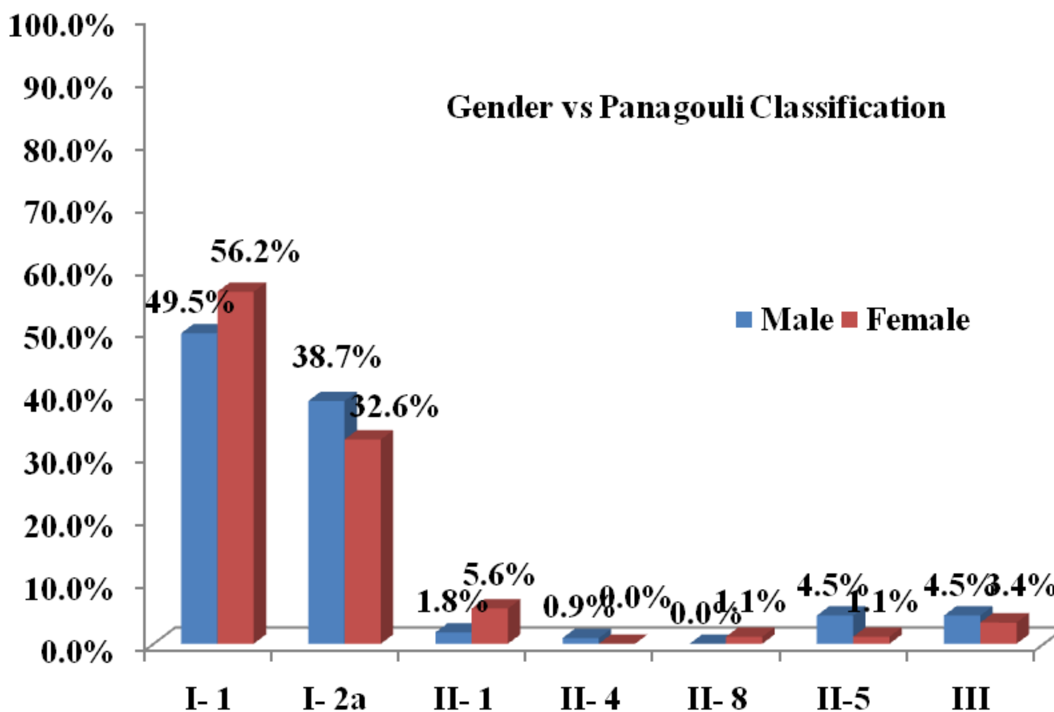

Figure 5: Bar diagram showing gender-wise distribution of celiac trunk variants of study population according to Panagouli classification

On analyzing the gender prevalence for the specific anatomical variant for celiac trunk variants under Panagouli classification it was observed that a there is slight female predilection in Type I-1 (Type I- Form 1) which is True tripod common origin of left gastric, common hepatic and splenic arteries (Tripus Halleri) (Male - 49.5% and Female - 56.2 %); Slight male predilection in Type I-2a, which is False tripod where there is division into two branches while the left gastric artery arises earlier along the celiac trunk ((Male - 38.7% and Female - 32.6 %). In Type II-1, female predilection was observed (Male - 1.8 % and Female - 5.6 %); Type II-4 showed slight male predilection (Male - 0.9% & Female - Nil); Type II-5 showed male predilection (Male - 4.5 % & Female - 1.1 %); Type II-8 showed slight female predilection (Male - nil & Female - 1.1 %) and type III showed slight male predilection (Male - 4.5% & Female - 3.4 %), however all the type shows no statistical significance (p value > 0.05).

Table 8: Gender-wise distribution of celiac trunk variants of study population by Uflacker's classification

Uflacker's classification of celiac trunk anomalies	Male	Female	*p* Value
Type I-c	55 (51.9)	49 (57.6%)	0.24
Type-I-NC	43 (40.6%)	29 (34.1%)	
Type II-Hepatosplenic trunk	2 (1.9%)	5 (5.9%)	
Type-III-Hepatogastric trunk	0 (0.0%)	1 (1.2%)	
Type-IV-hepato-spleno-mesenteric trunk	0 (0.0%)	0 (0.0%)	
Type V-gastro-splenic trunk	6 (5.7%)	1 (1.2%)	
Total	106 (100%)	85 (100%)	

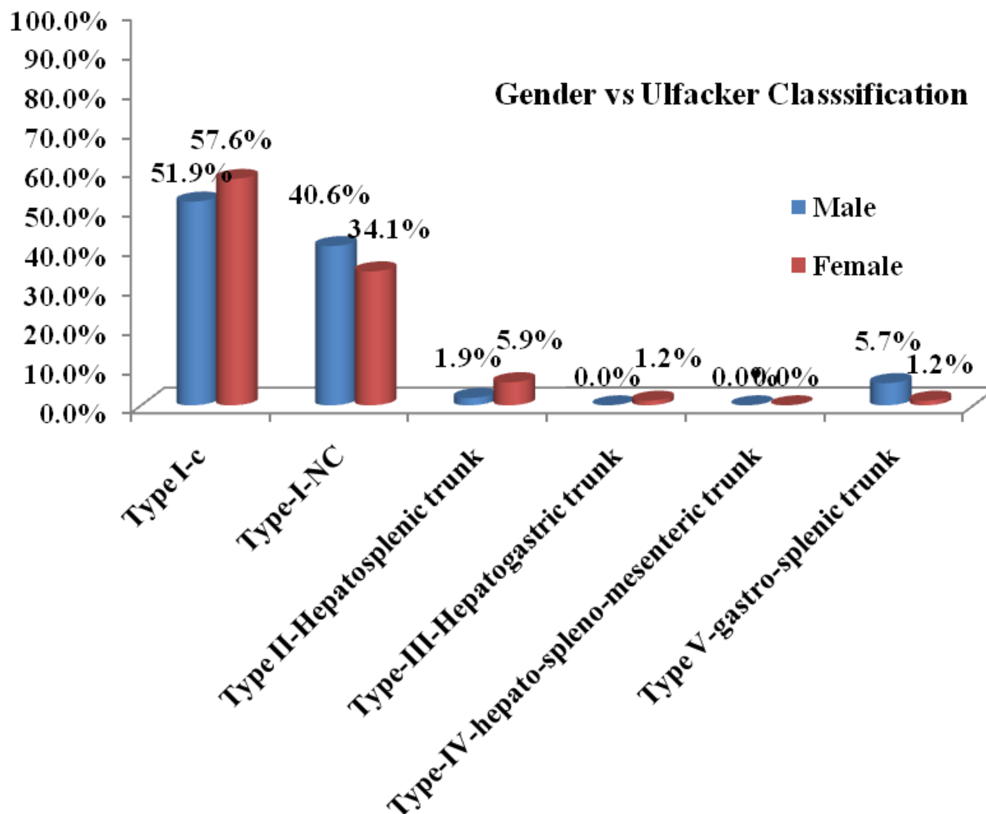

Figure 6: Bar diagram showing gender-wise distribution of celiac trunk variants of study population according to Uflacker's classification

On studying the pattern of celiac trunk variants by Ulfacker classification, it was observed that a there is slight female predilection in Type I-c (classic pattern) (Male - 51.9 % and Female - 57.6 %); Slight male predilection in Type I-NC (non classic)2a, which is False tripod (Male - 40.6 % and Female - 34.1%). In Type II, hepatosplenic trunk with left gastric artery from aorta, female predilection was observed (Male - 1.9 % and Female - 5.9 %); Type III showed presence only in 1.2 % of female participants, Type V showed male predilection (Male - 5.7 % & Female - 1.2 %); Type IV, common hepatic artery, Splenic artery & superior mesenteric artery has common trunk with left gastric artery arising separately from aorta was not seen in any on the population, however all the type shows no statistical significance (p value > 0.05).

DISCUSSION

The various anatomical variants of celiac trunk branching patteren analyzed in this study according to both Panagouli's classification and Uflacker's classification. According to Panagouli's classification it was observed that among the 200 participants included in the study, 105 (52.5%) showed type I-1 (True tripod), where there is trifurcation of the celiac trunk into left gastric artery, common Hepatic artery and splenic artery this is also known as 'Tripus Halleri', this was observed in most of the studies to be the commonest variant such as Koshariya et al, Gluck E et al and Iacob N et al [4,9,10]. Followed by which 72 participants showed type I-2a (False tripod) pattern where the left gastric artery is the first branch while the common hepatic and the splenic artery have a common point of origin, with 36% of the study population showing this pattern of bifurcation this is the second most commonest type in our study population which is contradictory to markedly lesser prevalence observed in similar study conducted by Koshariya et al [2] where among type 1- 6% showed from 2a, and 4% showed from 2b. None of our study population showed type I-from 2b or 2c.

On classifying the study population under Uflacker's classification it was observed that a majority of 176 participants fell under type I (91.62%) of which 104 participants (52%) showed type I-C, which is the classical pattern of trifurcation, and 72 (36%) participants showed I-NC which is the non classical pattern of trifurcation. This is in close coherence with results observed in study by Osman AM et al. [5] among Egyptian patients with 90.5% under type I Uflacker's classification.

Another important phenomenon in celiac trunk variants was the occurrence of additional branches, our study showed 8 participants (4%) to have additional branches of celiac trunk, classified under Panagouli's classification type III, of which the most common additional branch originating from the celiac trunk was bilateral inferior phrenic artery, directly from the celiac

trunk.

On analyzing the gender prevalance on celiac trunk pattern both classifications show slight female predominance in true tripod/ classic pattern; slight male predominance in false tripod/ Non classic pattern. In both classifications, Hepatosplenic trunk, left gastric artery arising from the abdominal aorta (Type II in Uflacker classification and Type II- form 1 in Panagouli classification)showed female predominance; Hepatogastric trunk with splenic artery from aorta (Type III in Uflacker classification and Type II- form 8 in Panagouli classification) was present only in female population in our study; Left gastric artery & splenic artery have a common trunk with the common hepatic artery arises separately from the aorta or superior mesenteric artery (Type V in Uflacker classification and Type II- form 4 in Panagouli classification) showed male predominance. In panagouli classification Type II- form 5, splenogastric trunk, common hepatic artery arising from the superior mesenteric artery shows male predominance and type III, additional branches, especially the inferior phrenic artery arising from celiac trunk shows sight male predominance.

Surgical implication:

Understanding the celiac trunk variants among the Indian population is very important for reporting diagnostic radiologists, interventional radiologists & operating surgeons as it plays a crucial role in identifying the anatomy of branches of the celiac artery, hepatic artery and inferior phrenic artery especially the origin and avoiding fatal complications during surgery [1,4,5,8,12]. Procedures like sleeve gastrectomy, pancreaticojejunostomy, pancreato-gastrectomy, liver transplant, tumor resection or chemoembolization of liver malignancy, splenectomy in case of traumatic injury or hypersplenism require detailed clear understanding of the arterial supply of the celiac trunk to plan the approach accordingly [4,5,8,13]. It is also essential to know the possible variants before proceeding with a hepatic or pancreatic cancer radioembolization or a transarterial chemoembolization (TACE) [5]. As there are many possible variants in the celiac trunk and its branches, it is very crucial for the reporting radiologist to have deep knowledge about the normal anatomy, possible variants of the celiac trunk and classifying the variants accordingly during presurgical evaluation & to prevent various complications [2,5,11].

Limitations:

Small sample size is the major limitation of this study. Few of the uncommon types described by Ulfacker (Types IV, VI-VIII) and Panagouli (few subtypes in Type I & II and Type IV-X in their classification were not encountered in our study which may be due to the small study population. Also 9 of out study participants with additional branches from celiac trunk (classified as type III under Panagouli classification) could not be classified under any category (type) under the Uflacker's classification as this classification did not include the variant with additional branches.

CONCLUSION

Multidetector computed tomography (MDCT) angiography is an effective tool for evaluating the variant anatomy of the celiac trunk branching pattern. Our study showed, bifurcation pattern and celiac trunk with additional branches can be commonest variants second only to tripod pattern. These variants can become complicating factors in treatment planning and pre-surgical evaluation and classification of such variants is very important in order to avoid the vascular complications.

REPRESENTATIVE CASES

CASE- 1

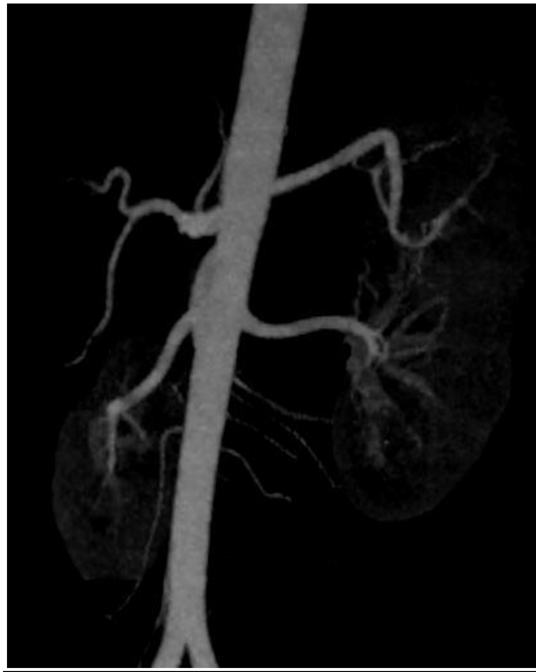

Figure 7.1

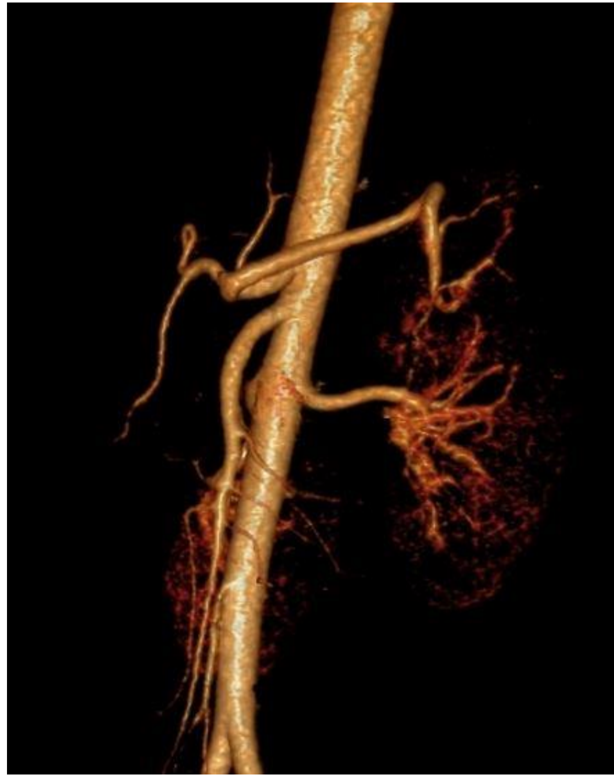

Figure 7.2

Figure 7: MIP (7.1) and volume rendering images (7.2) shows normal trifurcation pattern of celiac trunk - true tripod 'Tripus Halleri' ; Type I- C (Classic type) in Uflacker's classification and Type 1- form 1 in Panagouli classification.

CASE- 2

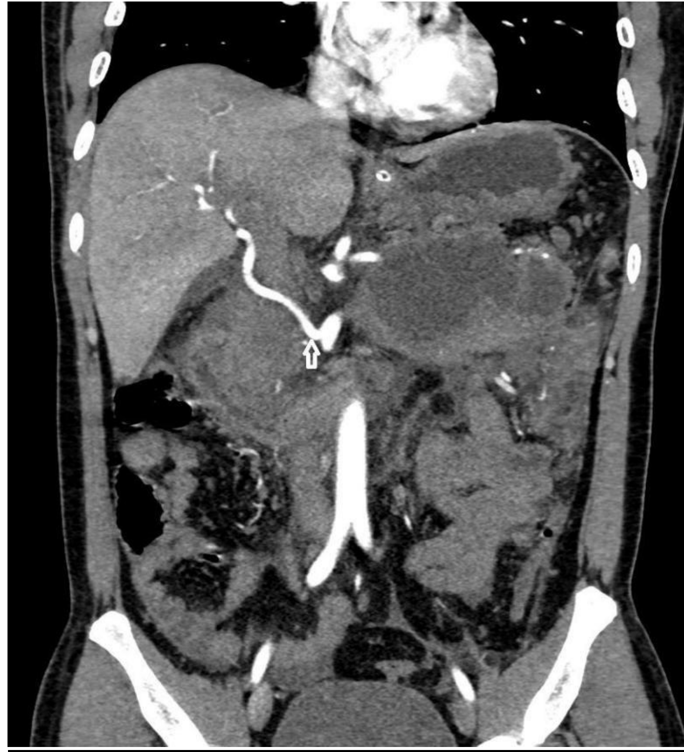

Figure 8.1

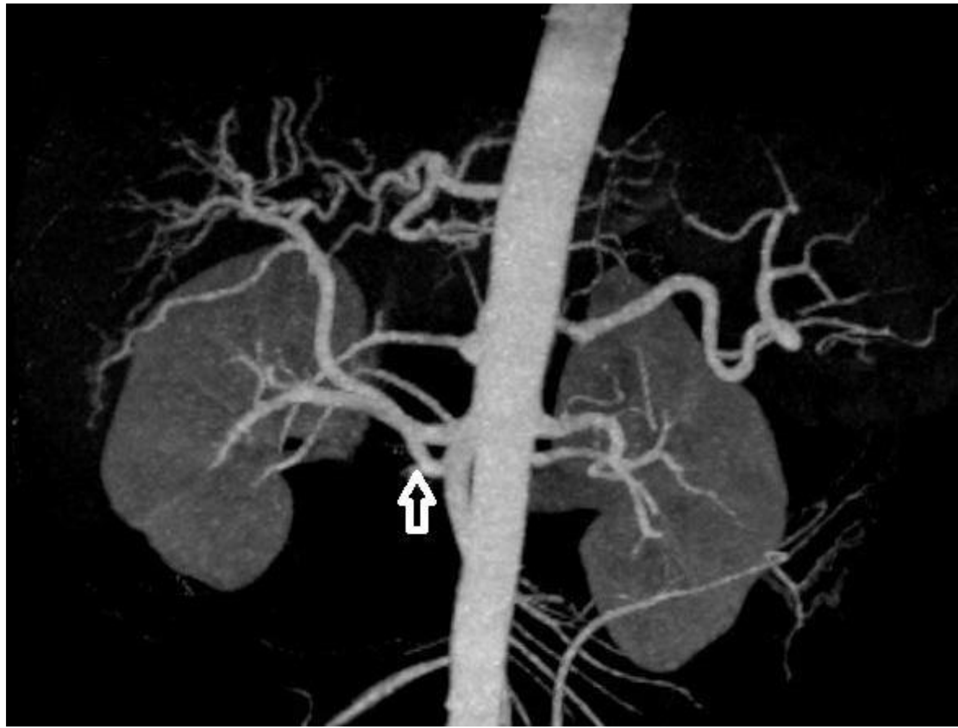

Figure 8.2

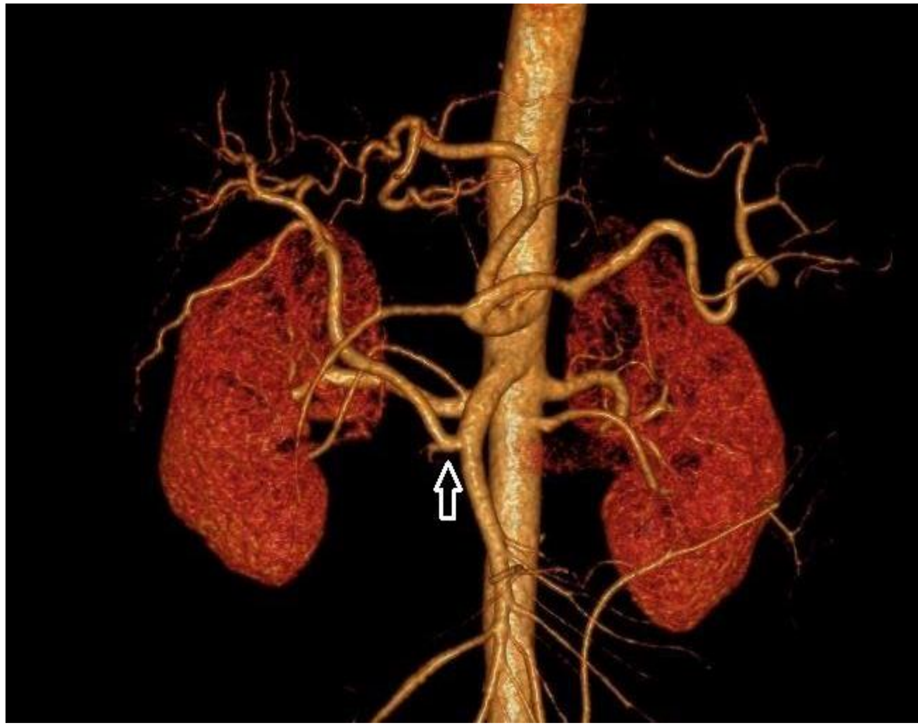

Figure 8.3

Figures 8: Coronal images of contrast enhanced CT in arterial phase (8.1), MIP (8.2) and volume rendering images (8.3) shows splenogastric trunk with common hepatic artery seen arising from superior mysenteric artery (White arrow); Type V in Uflacker's classification and Type II – form V in Panagouli classification.

CASE -3

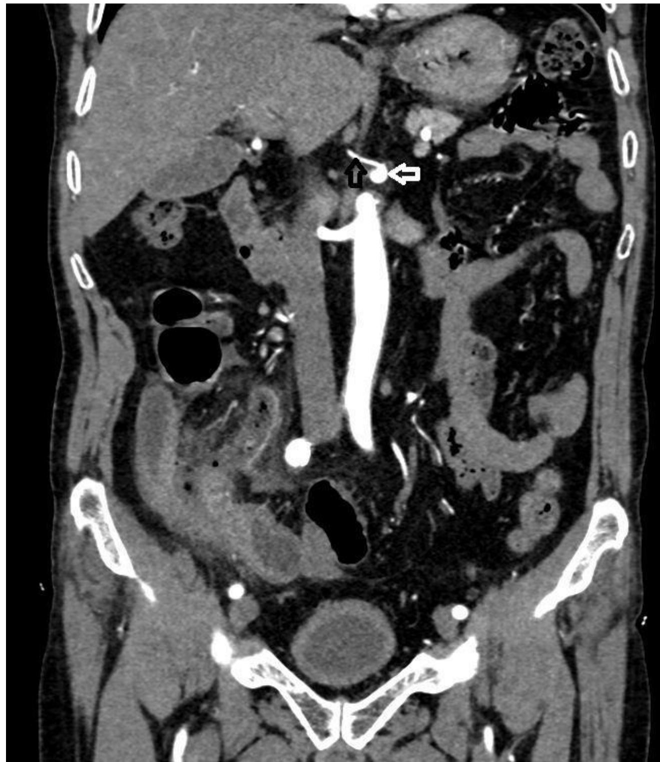

Figure 9.1

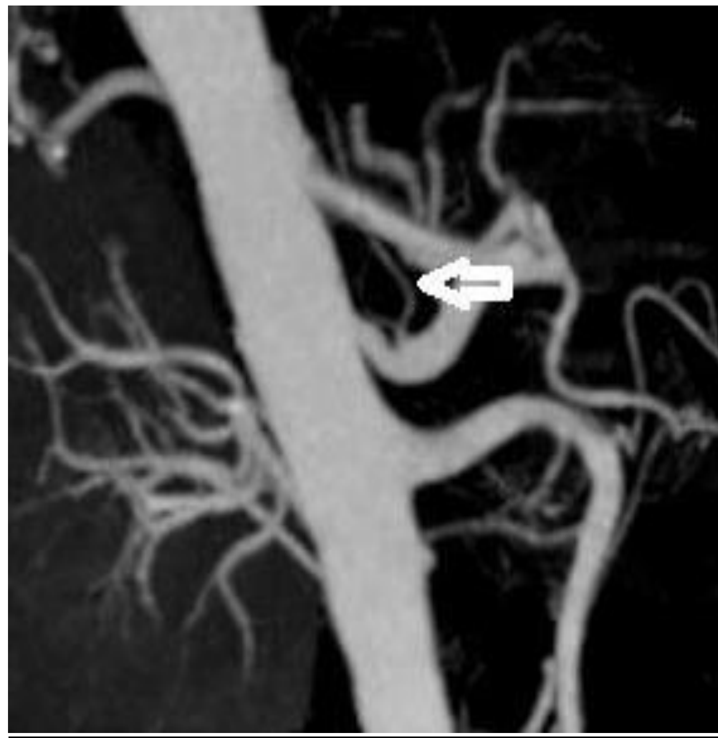

Figure 9.2

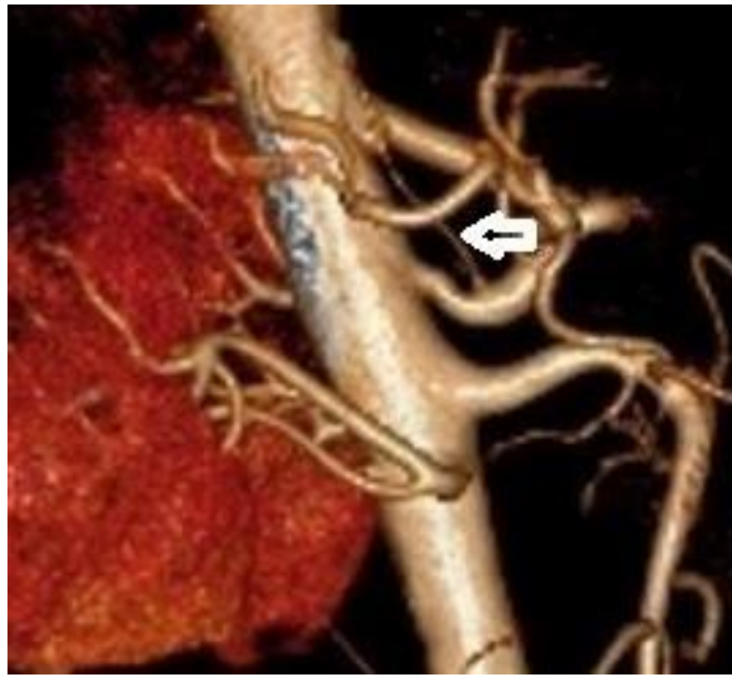

Figure 9.3

Figures 9: Coronal images of contrast enhanced CT in arterial phase (9.1), MIP magnified (9.2) and volume rendering images, magnified (9.3) shows right inferior phrenic artery (White arrow) arising from the celiac trunk ; Type III (additional branches) in Panagouli classification.

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